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Executive summary

The EuroSea project is improving the coordination of the European ocean observing and forecasting system to strengthen its capability of tackling the societal challenges related to ocean health, climate change, mitigation of ocean-related natural hazards, and the sustainable exploitation of marine ecosystem services in the Blue Economy.

The scientific excellence of the project is based on its better integration, assimilation, coordination and governance of methods, practices, and instruments to collect fit-for-purpose ocean data and the development of innovative tools and solutions to manage some natural coastal risks and support more efficiently fisheries and aquaculture.

The societal impact of the research and innovation activities carried out by the EuroSea consortium is enabled through the responsible research and innovation (RRI) policy concept implemented throughout the project progress development and, in particular, in the demonstrators work packages and in those activities focused on communication, dissemination, exploitation and legacy.

This report summarizes how the six articulations of the RRI approach were applied so far in the EuroSea project. It also offers some recommendations to boost the societal benefits provided by inclusivity, equality, ethics, transparency and collaborative co-design and co-creation in the research and innovation process applied to ocean observing. Now, and even more in the future, it is necessary to multiply the opportunities to share knowledge and expertise among all transdisciplinary actors to be engaged in improving the European and global ocean observing and forecasting.

Moreover, the emerging critical problems affecting the ocean require an increased public involvement through open access to ocean information, effective communication and dissemination of research findings, more diffuse ocean literacy and collective mobilisation. Only these factors seem to be able to establish the global common responsibility necessary to enhance the ocean sustainability, as advocated by the UN Decade for Ocean Science for Sustainable Development supporting the achievement of the SDG 14 in the UN Agenda 2030.

1. Introduction

The RRI approach in Horizon 2020

The concept of Responsible Research and Innovation (RRI) belongs mainly to the socio-economic science and humanities disciplines, but it is a cross-cutting issue in the Eight European Union Framework Programme for Research and innovation, named Horizon 2020. This participatory and inclusive approach in tackling the main societal challenges addressed in its second pillar by the EU programme for research and innovation was reminded in the H2020 call "*The Future of Seas and Oceans Flagship initiative*" which enabled the funding of the EuroSea project.

According to the European Commission's notion of RRI in Horizon 2020, responsible research and innovation seek to better align the process of science and technology and its outcomes with the values, needs, and expectations of the European society. This means that research, development, and innovation become targeted and focused on resolving present and future societal challenges, such as relevant diseases, food security and safety, climate change, diffuse pollution, energy supply, environmental protection, and finally ocean health.

As declared in 2013 by René von Schomberg, a former official of DG Research and Innovation of the European Commission, RRI is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the ethical acceptability, sustainability and societal

desirability of the innovation process and its marketable products. This way of thinking and doing, that guides research, development and innovation in ethically appropriate ways, foresees the active involvement of different actors, including citizens and third sector actors, to work together to collectively reflect on and discuss the questions of: *“What do we want research and innovation to achieve? What are promising paths to achieve these purposes?”* (Von Schomberg, 2013).

In fact, any RRI approach requires the involvement of many different players to improve relationships, create networks and communities of practice, build trust, and jointly enable scientific and societal progress. Research and innovation can be responsible in many ways: environmentally, ethically, socially, or politically.

The RRI implementation process must be initiated at an earlier stage, making some small steps first, for example diffusing knowledge and awareness of RRI and building collective interest in the concepts and their reputational benefit to companies and institutions, as well as encouraging open and transparent ways of engaging a range of publics including civil society and end-users.

This early involvement of all identified stakeholders in the RRI process facilitates communication and dialogue between these various actors through feedback to the scientists and /or industry representatives on how their innovations are perceived by individuals without scientific or technological training. This interaction contributes to the development of a shared language and common understanding that are essential for a meaningful and fruitful dialogue.

Considering the ethical, social, environmental sustainability of the EU policies for science that must be implemented **“with and for society”** (from the title of a specific research programme funded in Horizon 2020), the European Commission identifies six dimensions for the implementation of the RRI framework:

1. **public engagement** to bring together the widest possible diversity of actors including industry and SMEs, policymakers, non-governmental organisations (NGOs), civil society organisations (CSOs) and citizens and foster their dialogue and interaction in the co-construction of innovative solutions, products and services for better alignment with society’s values, needs, and expectations;
2. **gender equality** to integrate the gender dimension in the development of research and innovation activities and products to unlock the full potential provided by an open and inclusive cooperation of all interested subjects without any discrimination;
3. **science education** to make available to everyone languages and tools of science and technology, thus promoting future scientific progress and enhancing education processes by attracting new researchers and other societal actors with necessary knowledge to fully join responsible research and innovation processes;
4. **open science** to share scientific processes and outcomes and advance all together in research and innovation tackling societal challenges by providing free online access to results of publicly funded research including data and publications;
5. **ethics** to respect human fundamental rights and the highest ethical standards shared by the European society while ensuring open, responsive and transparent processes;
6. **governance** to design models of RRI implementation able to integrate all these six articulations and prevent harmful and unethical developments in research and innovation.

Responsible Research & Innovation



These practical articulations of the RRI approach in dealing with grand societal challenges should be integrated by four principles, defined by Stilgoe et al. (2013), that ask for increased organisational competencies and practices to reach responsibly considered innovative outcomes serving the general societal and environmental benefit.

These principles are: anticipation, inclusion, reflexivity and responsiveness (AIRR).

The goal of anticipation is to identify and appraise the possible impacts of research, development and innovation processes and results.

Researchers and innovators should be able to anticipate scenarios, technology evaluations, risk analyses, life-cycle assessments. They are asked to include new perspectives in science and R&I agendas through co-creation with stakeholders and citizens to better understand the implications and the socio-economic impacts of their activities.

Inclusion of diverse stakeholders (users, NGOs, etc.) in research and innovation processes is essential in offering more opportunities to solutions found by sharing different opinions and combining different interests.

Reflexivity is about integrating innovation into society and the kind of effect this new solution can have in practice. Therefore, researchers and innovators must think about their own ethical assumptions and their role and responsibilities in public dialogue.

Lastly, responsiveness is about policy and governance mechanisms for the practical implementation of responsible innovation and refers to the researchers' flexibility and capacity to change the R&I processes according to the public values through value-sensitive design, transparency, codes of conduct, established standards.

Being an approach that requires a lot of time, many diverse efforts and stakeholder engagement skills, RRI is more likely, nowadays, to be a process that is initiated and implemented by public researchers and innovators. In fact, they may see their interactions with multi societal actors as a duty that arises from the fact that their studies and products are funded through taxpayers' money.

2. Context and background

Ocean observing

The H2020 EuroSea project focuses on actions aiming at improving the European observing system by enhancing its design, coordination and governance through the integration of networks, datasets, standards and practices. It aims at increasing the operational level of the provided oceanographic services through innovative technological solutions developed in its demonstrators in close collaboration with stakeholders and end-users.

More precisely the objectives of the EuroSea project are:

1. Strengthening Europe's ocean observing and forecasting as an integrated entity within a global context;

2. Improving the design for an integrated European ocean observing and forecasting system for the European seas and the Atlantic, including the deep sea;
3. Improving and enhancing the readiness and integration of ocean observing networks;
4. Enabling FAIR (findable, accessible, interoperable, reusable) data, supporting integration of ocean data into Copernicus Marine Service, EMODnet and SeaDataNet portfolios;
5. Delivery of improved forecasts and new information synthesis products by better use of data in models;
6. Development of novel services, demonstrating the value of the ocean observing system to users;
7. Support of an integrated, sustainable, and fit-for-purpose ocean observing system by engaging with a range of end-users and other stakeholders.

In fact, ocean observing is a huge domain for scientific research and technological innovation, as the ocean is enormously vast, deep, and still mostly unexplored, despite its essential role for our daily life.

What is known is that the ocean covers 71% of the Earth's surface, measures 360 million square km, and contains 1,335 billion cubic km of water, i.e., the 97% of all water on our planet.

Therefore, seen from the space, the ocean is the dominant feature of the Earth, but under its surface lies an invisible world composed by abyssal plains at depths of about 4000-6000 meters, hills, underwater volcanic peaks, and depressions that can be very deep, such as the Mariana Trench in the Pacific Ocean that measures 11,000 meters under the water surface.

For thousands of years, Earth's inhabitants have been dependent on the ocean as a source for food and a route for transport, trade, and exploration of new territories. Nowadays, 40% of the world's population lives in coastal zones and 3 billion of people rely on the ocean for their daily livelihoods ([OECD](#)). The many economic activities that make use of the ocean and its resources are included in the definition of Blue Economy that is a sector with great potential for boosting economic growth, employment, and innovation. The Organisation for Economic Co-operation and Development, in its publication "The Ocean Economy in 2030" estimates that this productive sector will increase up to a value of 3 trillion of US dollar and 40 million of employments in ocean-based industries and commercial activities.

Marine aquaculture, capture fisheries, seafood processing, maritime transport, shipbuilding and repair, offshore oil and gas drilling, ocean renewable energy, seabed mining, coastal tourism, offshore wind energy, dredging, marine biotechnology are part of this economy based on the use of living and not living resources of the ocean.

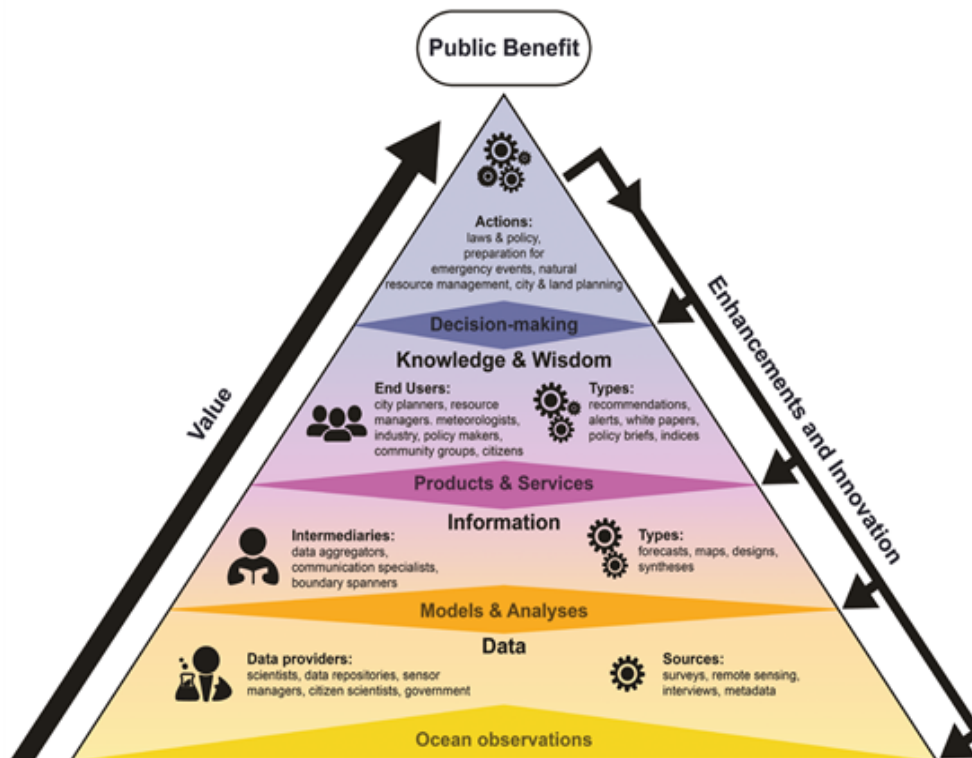
Ocean observation is crucial for the development of all these activities and for all the important marine and maritime ecosystem services that need to be exploited in a sustainable manner that considers the possible harmful impacts on the environment, as the ocean accounts for the 99% of the planet biosphere (IOC-UNESCO, 2022). Surveys, monitoring campaigns and sampling programmes carried out through many different instruments and facilities support the conservation of the marine habitats and increase the efficiency and safety of all the operational socio-economic and scientific activities performed at sea.

Many different types of ocean observations and predictions are constantly made in all parts of the Earth's globe to detect pollution, to track dangerous substances, to survey acidification and warming, to monitor changes in ocean circulation and health, and to forecast hazards such as floods or storm surges.

In fact, ocean ecosystems are subject to a multitude of stressors, including changes in ocean physics and biogeochemistry, and direct anthropogenic influences. The implementation of protective and adaptive measures for the sustainable management and conservation of the ocean ecosystems requires accurate observations of different kind combined with data analyses and prediction tools able to guide assessments of the current state of the ocean and its ecosystems.

These data are essential to highlight ongoing trends and shifts, anticipate impacts of climate change and support management policies. This information is necessary to provide decision makers and the public with the required knowledge to assess the impact of policy decisions and societal behaviours.

Many socio-economic benefits are generated by ocean observations, as marine data can be used to provide products that can be sold to support blue economy industries and commercial activities. Valuable profits are also associated with costs savings and increased revenues in gaining efficiency perhaps in maritime transport or by adopting science-based mitigation measures for avoiding possible risks, such as for instance pollution or coastal flooding.



Source: European Marine Board (2021), *Sustaining in situ Ocean Observations in the Age of the Digital Ocean*

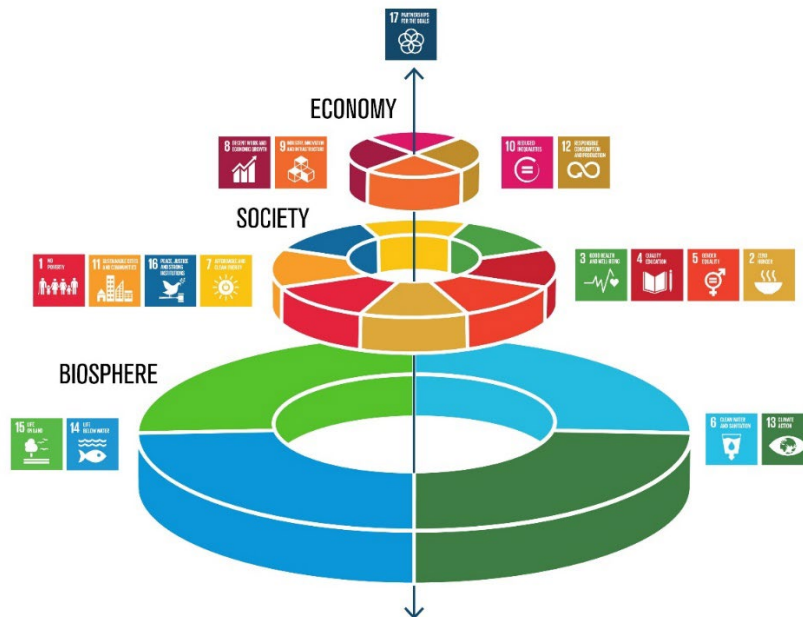
As shown in the above pyramid figure, ocean observations are at the basis of many operational services with socio-economic implications and support the efficacy of policy actions taken to meet relevant societal needs, such as the EU Marine Strategy and the Maritime Spatial Planning Strategy. The health of the ocean is a key priority also in the Green Deal, a policy of the European Commission to transform the EU economy into a carbon-neutral and more resource-efficient model of socio-economic development.

Therefore, ocean observing is an essential activity to understand the ocean processes, its influence on the coasts, climate, and livelihood of Earth's inhabitants. Knowing the tools and techniques to measure and analyse various geophysical, chemical, biological parameters is paramount for having accurate results and predictions. Turning these ocean observations into operational products and services is the best way of tackling the societal challenges related to the environment and taking care of public benefit and common good.

3. Societal challenges tackled by EuroSea

Better conditions in people's lives are foreseen in the 2030 Agenda for Sustainable Development adopted by all United Nations Member States in 2015. This UN Agenda provides a shared blueprint for peace and

prosperity for our planet and its inhabitants by fixing 17 Goals to be implemented now and in the future. These 17 Sustainable Development Goals recognize that ending poverty and other deprivations must go together with strategies that improved health and education, reduce inequality, and foster economic growth while encouraging the protection of natural resources. They address the global challenges faced by humans to improve their socio-economic status and achieve a better future.



Source: United Nations-The Sustainable Development Goals based on those related to environmental protection

The Sustainable Development Goal 14 titled “Life below water” concerns the good health of oceans and seas, the conservation and sustainable use of marine resources. It has 7 targets to be achieved by 2030 addressing marine pollution, environmental restoration, ocean acidification, overfishing, marine protection, the end of harmful subsidies and the development of small island States. To support this SDG that contributes to the achievement of the other ones, the UN Ocean Decade 2021-2030 was launched by the Intergovernmental Oceanographic Commission (IOC) of UNESCO with the following vision and mission:

- A clean ocean** where sources of pollution are identified and reduced or removed;
- A healthy and resilient ocean** where marine ecosystems are understood, protected, restored and managed;
- A productive ocean** supporting sustainable food supply and a sustainable ocean economy;
- A predicted ocean** where society understands and can respond to changing ocean conditions;
- A safe ocean** where life and livelihoods are protected from ocean-related hazards;
- An accessible ocean** with open and equitable access to data, information and technology and innovation;
- An inspiring and engaging ocean** where society understands and values the ocean in relation to human wellbeing and sustainable development.

The EuroSea project takes into account this global framework of strategies with its overall aim of delivering improved ocean observations and forecasts to advance scientific knowledge about ocean climate, marine ecosystems, and their vulnerability to human impacts and to demonstrate the importance of the ocean to an economically viable and healthy society.

The project activities and outcomes are connected to six of the ten societal [challenges](#) of the UN Decade of the Ocean Science for Sustainable Development:

- a clean ocean tackled in WP 2, 3, 5, 6;
- a healthy and resilient ocean addressed in all EuroSea WPs;
- a predicted ocean in WP 4, 5, 6, 7;
- a safe ocean in WP 4, 5, 6;
- a productive ocean in WP 1, 2, 3, 6;
- an accessible ocean in WP 1, 2, 7.

EuroSea, particularly in its demonstration activities in WP 5, 6 and 7, provides collectively beneficial operational services tackling the grand challenges of climate change, acidification, marine heatwaves, sea level rise, plastic pollution, nutrition, and health. These services are based on its integrated ocean observing and forecasting system developed through the activities performed in the WPs 1, 2, 3, 4. This more coordinated and strengthened system has been used to support important sectors of the blue economy such as aquaculture and fishery, to improve the management of possible coastal risks due to marine extreme events and to develop new ocean-climate indicators for assessing the carbon fluxes and uptake in some Atlantic areas and in the Western Mediterranean.

More in detail, to meet the safety needs of port authorities and coastal communities the project team involved in WP 5 developed the OSPAC (acronym of Oceanographic Services for Ports and Cities) monitoring system to deliver real-time alerts by SMS and emails to provide forecasts of sea conditions, rip currents, flushing times, floating debris, inundation, and erosion risks. This tidal station tested in the port of Barcelona and Taranto will be also operational in the Buenaventura in Colombia thanks to an international cooperation in implementing operational services able to increase coastal protection worldwide.

Linking ocean observation to fisheries assessment and opportunities, two innovative buoys were deployed by the EuroSea team of WP 6, in close cooperation with a fish farming industry and other stakeholders such as seafood companies, government agencies, academic institutes. This monitoring and forecasting system based on sensors, telemetry solutions, buoys, moorings, and platforms serves to optimize aquaculture operations and reduce financial losses from stock damage caused by extreme marine events or other possible environmental hazards.

EuroSea WP 7 has successfully developed societally relevant predictions of ocean variables and indicators in seasonal forecast systems to improve decision-making on the sustainable management of ocean resources. The ocean-climate related demonstrator is based on more accurate estimates of the value of the ocean carbon sink also from the economic point of view, thanks to a combination of scientific and economic methodologies aimed to provide a more accurate carbon audit as an indicator of the Copernicus Marine Service ([CMEMS](#)).

4. Implementation of RRI in EuroSea

As an Innovation Action funded by the programme H2020, the EuroSea project is focused on new solutions to improve the European and global ocean observing and forecasting system to deliver better products and more efficient services, thus increasing their scientific, technological, and societal impact. The policy framework for the project implementation is the declaration on “*The Future of the Seas and Oceans*” of the Tsukuba Communiqué signed by the G7 Science and Technology Ministers after their meeting in Japan from May 15 to 17, 2016. Five actions in support of the achievement of the SDG14 were launched among which the enhancement of ocean monitoring and global data sharing.

In September 2017, the G7 Turin Communiqué reiterated these actions related to the future of the seas and oceans and recommended the realization of a more efficient and effective network of scientific ocean observing to assess and forecast the state of the ocean and changes, also through stakeholder engagement and identification of user needs.

Consequently, RRI (Responsible Research and Innovation), as policy approach to perform science and technology **with and for society**, is not a foreground topic in EuroSea, even if it is taken for granted by the consortium that research and innovation exist to serve society.

In the EuroSea Grant Agreement RRI is explicitly quoted as a project objective only in the WP 8 description where there is a reference to the knowledge and technology transfer to be done in this WP focused on communication, engagement, dissemination, exploitation, and legacy.

Therefore, only the team involved into WP 8 has some competencies in the Sciences and Humanities disciplines. All the other WPs and tasks are in charge to experts in physical, chemical and biological oceanography, hydraulic engineering, ocean modelling, marine ecology, ocean circulation, coastal dynamics, operational oceanography, marine biochemistry, data assimilation, telecommunications, computer engineering, ocean and climate dynamics, chemistry, mathematics, ecosystem modelling, marine biogeochemistry, physics.

Considering this scientific and technical expertise in the project consortium and the prevalence of professional curricula in oceanography, marine sciences and disciplines connected to the core-business of the EuroSea activities, WP 8 circulated to all partners a factsheet on RRI in February 2020, at the early beginning of this collaboration among 55 (now 53) public and private organisations.



Responsible Research and Innovation in Ocean Observing and Forecasting

- Expand your stakeholder networks and learn how to engage effectively
- Ensure a long-term impact of your R&I results
- Benefit from the latest approaches in stakeholder co-design in Research and Innovation

EuroSea Vision:
 'Advance research and innovation towards a user-focused, truly interdisciplinary, and responsive European ocean observing and forecasting system, that delivers the essential information needed for human wellbeing and safety, sustainable development and blue economy in a changing world.'

EuroSea is a European Union project working to improve coordination in ocean observing and forecasting to answer the evolving demands for ocean knowledge and information, underpinning sustainable blue economy and maritime services. New research and innovation will be generated in three EuroSea demonstrators improving oceanographic services and forecasts for port operations and environmental monitoring, food from the ocean activities, and the understanding of the ocean and climate continuum.

These new EuroSea oceanographic services and products will be delivered to and for society so they cannot be designed without engaging with a broad variety of ocean stakeholders (e.g. industries, NGOs, policymakers, national agencies, etc.). Using the Responsible Research and Innovation (RRI) approach in EuroSea will help boost the stakeholder co-design and exploitation of the EuroSea project results. Furthermore, this will contribute to draw and share best practices in RRI in the context of ocean science, technology and innovation.

The RRI concept helps to engage societal actors to work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of the European society. RRI has been actively promoted by the European Commission since 2012.

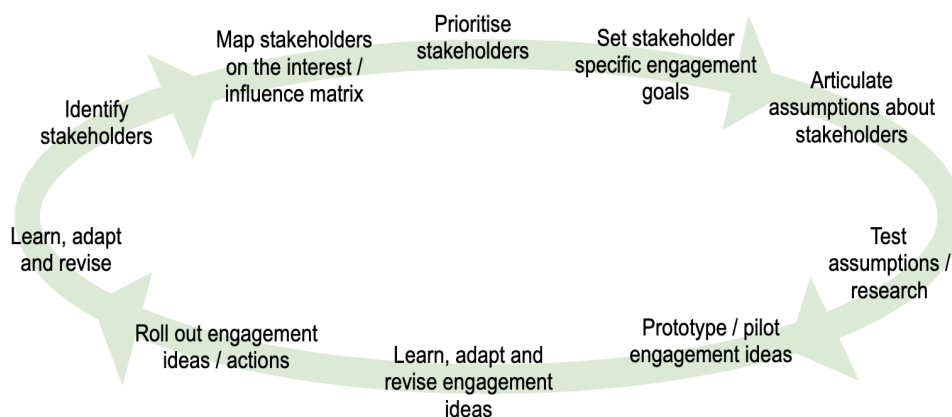
What is Responsible Research and Innovation (RRI)?
 The RRI framework consists of six dimensions:

- PUBLIC ENGAGEMENT**
Bring together the widest possible diversity of relevant actors including industries, policymakers, non-governmental organisations, civil society, and citizens - to foster their dialogue and interaction.
- GENDER EQUALITY**
Integrate the gender dimension in the development of research and innovation activities to unlock their full potential through an open and inclusive cooperation.
- SCIENCE EDUCATION**
Explain aims, activities and results of science and technology bringing science closer to society and promoting the scientific and societal progress.
- OPEN ACCESS**
Share scientific processes and outcomes and advance all together in research and innovation tackling societal challenges.
- ETHICS**
Respect and promote fundamental human rights and the highest ethical standards shared by the European society.
- GOVERNANCE**
Design models of the RRI implementation to integrate all these six articulations into your own projects and activities.

RRI implies engaging multiple stakeholders in the planned scientific activities and jointly determining their goals, purposes and trajectories. RRI suggests that research and innovation are underpinned by shared values and co-created by all stakeholders committing themselves to the scientific and technological process for the common interest and benefit. This approach helps to build trust, create networks, enhance synergies and communities of practice, and jointly enable scientific and societal progress and responsibility.

This factsheet, also published on the project [website](#), was aimed to explain the societal values to be considered in performing science and technology and to raise awareness on the benefits provided by this approach to the ocean observing and forecasting community while engaging with stakeholders, end-users and representatives of other socio-economic sectors.

Later, from September 2020 to March 2021, the WP8 coordinator organized a training course on stakeholder engagement composed of four lessons developed according to the following scheme:



Source: Green Bright Learning –Stakeholder engagement pathway

The main goal of this training course was to enhance the consortium's capacity in developing fruitful interactions with multi-stakeholders and end-users of the project products and services in their starting and following phases. Even if the course was not always participated by many attendants, this shared, and successively well-disseminated experience, has been very useful in providing knowledge on how to manage the necessary co-creation process in the demonstrator WPs.

In the development of the EuroSea activities, **stakeholder involvement and public engagement** are not coincident. The public and private organisations involved in the demonstrators WPs developed their activities and their innovative products in close collaboration with the identified stakeholders: port authorities, members of fisheries and aquaculture enterprises, decision-makers and those categories of socio-economic actors with a direct interest in the project outcomes.

On the contrary, public at large usually is not aware of the topic addressed by the researchers working for the project. Citizens' attention to the societal challenge of improving the ocean knowledge to protect the essential marine ecosystem must be attracted in a different and more demanding manner.

In April 2020, the EuroSea Communication Plan (Deliverable 8.1) identified the project stakeholders and a set of communication tools to open a dialogue and engage with them. In this document, society and general public represent a different targeted audience who need to improve their ocean literacy through specific information messages and communication initiatives able to raise their interest and awareness in the societal relevance of ocean monitoring.

For researchers and innovators dealing with stakeholders is easier and less time-consuming than interacting with citizens, because generally these have not a professional background or economic interest, public responsibility or societal influence that enable the establishment of a dialogue focused on the project results.

Besides using the social networks as communication channels, EuroSea WP 8 chose to engage with public at large through its itinerant exhibition that was displayed during some major international conferences focused on marine sciences and ocean literacy, thus contributing also to another RRI articulation: science education. Composed of 12 cardboard panels showcasing the goals and achievements of EuroSea through attractive images, the exhibition was presented, for the first time, at the [ICYMARE](#) international conference for young marine researchers, held in Bremerhaven on 14th of September 2020, where a short workshop was organized to speak about the EuroSea activities.

Shortly after this event, the exhibition was used during the Science Day at GEOMAR attended by almost 150 people. On 30th September, as part of the celebration of the [European Researchers' Night](#), the exhibition proved to be again a unique opportunity to engage with citizens of all ages to raise awareness about EuroSea in other countries of the consortium partners. SOCIB, the partner in charge of the realisation of the exhibition panels, engaged citizens on the topic of ocean observing also providing Spanish and Catalan translations of the printed English texts to ease their understanding and interaction with the presenting researchers (Deliverable 8.5).



As already mentioned, initiatives of **science education** were mainly performed during the European Researchers' Night by using the itinerant exhibition as a tool to communicate with pupils, students and their families visiting the various events organized with the contribution of some EuroSea partners to promote the importance of science for the modern society. To inspire the next generation of scientists in ocean observing, monitoring and forecasting, during the ICYMARE conference in Bremerhaven, a publication showcasing a variety of [job profiles](#) from EuroSea associates was presented and distributed to the young visitors. Guided tours of the SOCIB research vessel, an activity titled '*Beer with a scientist*' and a workshop for kids were other educative initiatives organized in Palma de Mallorca to enable the targeted audiences to discover marine research and the impact of the ocean and marine sciences on our daily lives.

Another important activity of science education is realized through the activities of the [Floating University](#) on the research ice breaker Polastern, an annual cruise organised in March to host African students who receive oceanography lessons during the track from Cape Verde to Bremerhaven. This year the students were engaged on the EuroSea activities by the researchers of the German partner GEOMAR (EuroSea coordinator) and the Institute Alfred Wegener, a partner organisation also based in Kiel. Other networking opportunities focused on career development and possible future jobs inspired by oceanography were planned after the cruise.

Another occasion to dialogue with the youth and offer them direct insights into ocean science was the EuroSea annual meeting held in Cadiz from 9th to 13th May 2022. A dozen of students from some European universities were invited to attend the works of this periodical meeting organized annually by the consortium to take stock of the project progress and to agree on the next steps to achieve the intended results.

Other opportunities for public engagement and science education on ocean observing through the EuroSea itinerant exhibition are offered to the project consortium by other events organized in May, June, September and October 2023 in Mallorca, Genua, Paris and Vigo (Deliverable 8.5).

Stakeholder involvement, public engagement, science education and, ocean literacy, are eased through **open access** to the whole information and new knowledge produced during the project life span, in compliance with the funding requirement of the H2020 programme. The EuroSea [website](#) is an open access portal where it is possible to consult the reports on the results so far achieved and get an insight into relevant news and periodical events.

Some partners of the consortium have written scientific papers that are all freely accessible in the peer-reviewed journal “Frontiers in Marine Sciences”. A first list of these scientific publications is provided in the dissemination paragraph of the deliverable 9.2 available from the EuroSea website. The addressed topics concern the activities developed in the project WP 1, 3 and 6.

Moreover, the open science principle, which is an enabling factor for increasing transparency, accessibility and participation in research and innovation, supports the production of FAIR (findable, accessible, interoperable, reusable) data through shared methodologies and tools used by the public and private EuroSea partners in the project activities co-developed with their targeted stakeholders and end-users.

As for **gender equality**, there are no problem of women’s under-representation and scarce empowerment in the EuroSea consortium. Female researchers are equal, or even more in number in the partnership and many of them lead WPs and tasks for their acknowledged competency in the activity to be realized in the project.

Nevertheless, to comply with the gender balance fostered by the European Commission with its [Strategy](#) (Communication 152 final dated 5-3-2020), EuroSea has a [Gender and Diversity Board](#). Its main task is to draw the attention of the large scientific community involved in the European ocean observing system on the multiple benefits provided by the proactive inclusion of all the diverse actors with their different ideas, skills, and perspectives in developing new solutions for progressing research and innovation, in Europe and beyond.

In 2020 and in 2022 this Board circulated within the EuroSea consortium a questionnaire to collect data on some indicators related to gender equality and equity: career advancement, leadership, diversity pay gap, part-time employment, women’s representation in boards and committees, recruitment, sensitive language. The questionnaire was focused on the internal staff of each partner organisation and aimed to provide an updated picture of inclusion and equality in the European institutions with responsibility an competencies in ocean observing and forecasting.

Furthermore, the role of women in oceanography was recalled during the EuroSea Annual Meeting held virtually in January 2021 with a [presentation](#) of the researcher Britte Thege of the Institute for interdisciplinary gender research and diversity in Kiel University of Applied Sciences. She also reported on the equity survey highlighted in the updated handbook of gender-sensitive indicators in the Baltic Gender project funded by Horizon 2020.

Ethics is closely linked to the RRI concept, as researchers and innovators, together with societal actors, become mutually responsive to each other in the co-creation process of new scientific and technical solutions that are desired or positively accepted by society, because of their improved socio-economic impact and environmental sustainability. The activities developed by EuroSea and in particular the innovative technologies and products realized within the demonstrator WPs are perfectly in line with these ethical requirements. They are meant to increase the protection and resilience of coastal zones to flooding, sea level rise and extreme hydrological events, to improve the production of seafood and contribute to the knowledge on the ocean-climate dynamics. During the creation process, evaluation and control of these benefits were ensured through the close interaction with the identified stakeholders.

As for the implementation of the RRI articulation **governance** in EuroSea, the UN Decade of Ocean Science for Sustainable Development (2021-2030) is recognized by the consortium as an excellent opportunity to boost research and innovation in ocean observing and forecasting and connect these services to the societal needs. In fact, the Ocean Decade represents the blueprint for the present and future governance of the ocean

protection, a global policy framework able to integrate the scientific knowledge with the social, cultural, and economic values connected to the ocean's role in sustaining life on Earth.

Supporting effective management of the ocean resources through a collective mobilisation of all involved actors in ocean sustainability is also recommended in the G 7 Tsukuba and Turin Communiqués that mainstream the EuroSea project activities.

With the main goal of improving ocean protection governance through collective responsiveness, accountability, and anticipation, the EuroSea consortium issued the Policy Brief *"Nourishing Blue Economy and Sharing Ocean Knowledge"* with a group of other H2020 projects presented to the European Commission in October 2021.

Frequent interactions with other relevant policy makers with a say on strategies and roadmaps focused on foresight initiatives in ocean observing and forecasting have been developed since the launch of the project (EuroSea Deliverables 1.1 and 8.3).

5. Recommendations

According to article 19 of Regulation 2021/695 establishing Horizon Europe, the next research and innovation framework programme after Horizon 2020, the EU-funded research must comply with ethical principles and relevant European, national, and international legislation, including the EU's Charter of Fundamental Rights and the European Convention on Human Rights and its Supplementary Protocols.

To move from this Responsible Research and Innovation conceptual framework to a practical implementation of this approach by organisational structures and systems where these societal values are fully embedded, it is necessary that a close and active collaboration with all actors in society is started very early in the developing scientific process. This interactive dialogue must be kept alive during the whole progress of those scientific and technological initiatives aimed to tackle relevant present and future challenges, until the final achievement of the co-created results.

As already stated, EuroSea brings together key European actors of ocean observation and forecasting systems with key end-users of these ocean data across different countries, disciplines, and type of organisations. From its beginning, the project has evolved in a platform, where scientific evidence, best practices on ocean observing and lessons learned on knowledge exchanges with multi-stakeholders are shared and collectively developed.

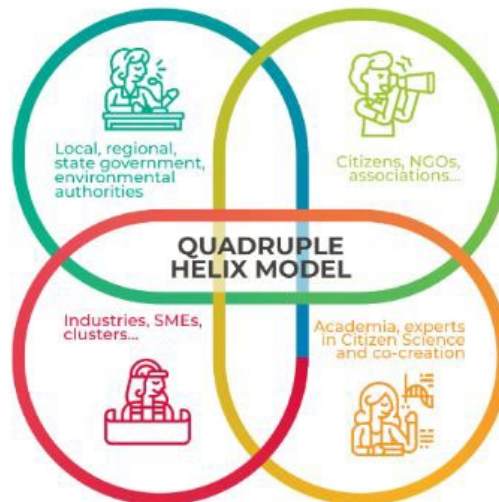
The beneficial impact that research and innovation in ocean observing and forecasting can have on society's wellbeing depends on the capacity of advanced ocean monitoring systems to deliver services essential to the socio-economic progress of humanity.

To improve this capacity some recommendations based on the RRI approach are listed below:

INCREASE PARTICIPATORY PROCESSES TO BUILD COMMON RESPONSIBILITY TOWARDS THE OCEAN

Awareness on the essential role of the ocean for the planet's biodiversity, the climate system and the water cycle should be spread, as much as possible, among Earth's inhabitants, as they daily take huge socio-economic advantages from the large range of ecosystem services provided by the ocean. Active partnerships in research and innovation applied to ocean monitoring to support a sustainable use of its resources bring many benefits to environmental protection, as the implementation of the related policies proves to be more effective, if the whole society is fully aware, literate, and engaged.

Organizing frequent participatory processes based on the quadruple helix model that involves the four identified categories of relevant societal stakeholders can guarantee transparency, reliability, accountability, and consequentiality to the production of new research and innovation aimed at solving complex modern challenges.



In fact, meaningful Responsible Research and Innovation can be more easily achieved through an open and honest dialogue based on mutual trust between the actors who promote and develop new scientific and technical solutions to a big societal challenge and the other people who enable the implementation of those tools and measures aimed to overcome that focused critical problem.

As shown in EuroSea, it is the development of new technological products that offers great opportunities to establish close interactions and synergies with all stakeholders in ocean observing and forecasting. This co-creation process, based on shared values and common goals, should be enhanced in the future to increase co-responsibility of all people in sustainable management of the ocean and its essential resources.

BETTER INTEGRATE MARINE SCIENCES WITH SOCIAL DISCIPLINES

Ocean sustainability is the main priority for oceanographers, but it should be an important issue also for the whole civil society who bears the responsibility of the Earth's protection. Such a key societal challenge must be tackled with different points of view and vary scientific perspectives.

Social sciences arts and humanities can increase the general impact of research and innovation, as they are focused on the social, cultural, democratic concerns of the modern society. For achieving an effective implementation of the RRI concept in ocean observing, thus boosting the common responsibility towards the ocean protection, it is necessary to build transdisciplinary partnerships. These teams characterized by different knowledge and experience backgrounds can better enhance the capacity of building fruitful interconnections with multi-stakeholders and pave the way to mutual understanding and beneficial mobilisation of all actors involved in the research and innovation process. Usually, they are also best prepared to generate impactful solutions through cross-cutting thematic studies and multidisciplinary approaches that look at ocean science from several perspectives able to optimise scientific cooperation by combining a diverse range of expertise.

ALLOCATE REASONABLE TIME, SUFFICIENT FUNDS AND ADEQUATE HUMAN RESOURCES TO ENGAGE WITH SOCIETAL ACTORS

As experienced in EuroSea, the implementation of the RRI approach in science aimed to provide solutions to grand societal challenges enriches the research and innovation process, because it helps the developing of new technologies, products and services that are co-created with end-users and are socially acceptable for their contribution to collective values. This long-lasting and demanding engagement with societal actors in the uptake of innovations requires consistent efforts in time and money. Adequate skills for developing positive actions with multi-stakeholders and taking the best impact from these societal interactions are also needed. Purpose is the strongest driver of co-creation in research and innovation that serve societal goals. Therefore, it is important that research organisations and innovators plan in their programmes and projects, early in advance, this allocation of efforts aiming at improving the societal relevance and benefit of their final products.

TAKE CARE OF THE INCLUSION OF THE UNDER-REPRESENTED PEOPLE IN SCIENCE APPLIED TO THE OCEAN

To Increase impact of ocean observing and forecasting in providing useful services to society, all doors must be open to historically marginalized categories of people to boost inclusion in the common goal of protecting the ocean and its valuable resources. Equality, diversity, and inclusion ensure that all roles within the research and innovation are accessible to all regardless of gender, age, ethnicity, disability, status, nationality, religious affiliation, sexual orientation, and socioeconomic background. Still, the scientific community lacks social diversity, especially regarding the participation of women, people with disabilities, racial minorities, and other underrepresented groups. Only experiences, competencies, skills, and merits of individuals should be considered in the research and innovation processes and the organisational structures that govern them. In this manner, a loss of potential talents is avoided, and more professional blue skills are created to serve the interests of the entire human community.

CREATE CONNECTIONS AND NETWORKS TO IMPROVE OCEAN OBSERVING GOVERNANCE

Given the ocean's essential role in absorbing significant amounts of heat and carbon dioxide, and in providing invaluable ecosystems services for common socio-economic growth, it is paramount to build alliances in ocean sustainability. In fact, emerging global challenges facing the ocean require the collaboration of researchers, policy makers, citizens, representatives of industries and businesses at all levels of engagement and mobilisation. Possible critical situations can be addressed effectively, if active partnerships among multi-stakeholders are established to share knowledge, experiences and best practices in ocean monitoring and protection. These useful and cross-sectoral synergies enable the creation of a community that becomes more responsible of taking concrete actions at each level of territorial competence, thus enhancing mutual understanding and general capacity building in finding effective solutions. The participation of all actors, with their different interests, needs and concerns, in collaborative actions focused on the ocean strengthens the societal impact of research and innovation applied to marine sciences. Furthermore, the densification of such cooperative networks better supports the design and the delivery of the global ocean observing system and its capacity to deliver multiple collective services. Finally, the engagement of all stakeholders can enhance the general resilience to possible ocean-related hazards.

ENHANCE OPEN ACCESS TO OCEAN SCIENCE

Further efforts can be done to make research and innovation on ocean observing more accessible and understandable to broader publics beyond the researchers' community. As research is mainly funded through public funds, it is part of the scientist's work to involve policy makers and other stakeholders in the production of results able to solve socially relevant problems. In fact, ethics, integrity, and scientific evidence should underpin all public policies. In any case, open access to science represents a strong incentive to

improve the quality and the impact of research and innovation activities across their lifespan. Open access to data, information and findings is based on transparency, and increase the reusability of knowledge and the trustworthiness in scientific results that are shared and accessible for examination, reuse, and further evaluation.

As stated in the EC publication "[The economic impact of open data](#)" (2020), free access to new knowledge and its reutilisation in different business models enable the generation of considerable socio-economic values.

IMPROVE COMMUNICATION ON OCEAN RESEARCH AND INNOVATION

Understanding information is the foundation of effective co-responsibility in ocean protection. Clear, trusted, accurate and accessible information on the present and future challenges concerning the ocean's health is critical to ensure useful synergies and complementarity between actors in different scientific, political, economic, and social environments. Effective communication is an essential element to start and keep a long-term collaborative dialogue with stakeholders and engage society in the beneficial process of exchanging ideas, needs and values, thus paving the way to the co-creation of responsible research and innovation. Simply, direct, and concrete messages, adjusted to the targeted category of stakeholders, and circulated through the best available channels, must be integrated constantly in the realisation process of scientific and technological activities, as they contribute to improve reliability, respect, accountability, and societal legitimacy of the products and services developed through research and innovation initiatives. Ocean sustainability is a complex and multidisciplinary topic that is open to many questions and answers. Therefore, a successful communication can take great advantage in proactively implementing the RRI approach in informing, disseminating and building societal engagement on ocean science.

BOOST OCEAN LITERACY AND EDUCATION

Ocean Literacy is a strategic enabler to engage with policy and society on the topics of ocean sustainability, ocean observations, and the use of oceanographic products and services to provide solutions to grand challenges. Ocean Literacy is described as "***The understanding of the ocean's influence on us and our influence on the ocean***" and is defined by the following seven principles:

Earth has one big ocean with many features; the ocean and life in the ocean shape the features of the Earth; the ocean is a major influence on weather and climate; the ocean makes Earth habitable; the ocean supports a great diversity of life and ecosystems; the ocean and humans are inextricably interconnected; the ocean is largely unexplored.

These principles build the legitimacy of a global ocean observing and forecasting system and appeal to an increased societal and policy awareness of the needs, challenges and opportunities of ocean monitoring to better understand our relationship with the ocean. Consequently, researchers and innovators in marine sciences should create continuous opportunities to focus on science related to the ocean and find diverse and effective tools and approaches to increase the education and culture focused on ocean sustainability.

EMBED SUSTAINABLE DEVELOPMENT GOALS IN OCEAN OBSERVING

Societal impacts of a strong integrated ocean observing capacity at European and global level must include the sustainable development goals addressed in the UN Agenda 2030 that is focused on the achievement of universal human fundamental rights. Improving ocean observing capacity through sharing scientific knowledge and joint planning of research activities contributes to foster equity in science, technology, and innovation, with the aim of making ocean observations a public utility. To meet this impactful goal, it is

important that the FAIR principles encouraging open data are combined with the CARE principles that consider people with their demands and values.



Source: Global Indigenous Data Alliance – CARE principles for indigenous data governance

6. Conclusion

The RRI approach provides a critical reflection on the role of science applied to solve relevant societal challenges. Its implementation is focused on the necessary practices to increase the societal impact of research and innovation aligned with the needs, motivations, perceptions, expectations, concerns, and interests of the modern society.

Responsible Research and Innovation (RRI) implies that all societal actors (researchers, industries, citizens, policy makers, business representatives, organisations, associations, etc.) work together during the whole research and innovation process so as share useful transdisciplinary knowledge and jointly benefit of the final cooperative outcomes.

The EuroSea project contributes to advance science and technology in ocean observing and forecasting to efficiently sustain the blue economy and prevent possible hazards related to climate change and extreme hydrological events. The project implements the RRI approach in its activities through a close and constant engagement with stakeholders, and thanks to many ocean literacy initiatives supported by open communication and frequent dissemination of progresses and results.

This attention to the societal impact of its activities and products helps the EuroSea consortium build fruitful partnerships with multi-sectoral actors in strengthening ocean monitoring and enhancing the common responsibility towards the achievement of the Sustainable Development Goal 14 in the UN Agenda 2030.

Based on the experiences gained during the project progress some recommendations on the further implementation of the RRI concept in ocean observing are proposed in this report. They are targeted to researchers, innovators, funding agencies, decision makers and other interested stakeholders, and intend to contribute to the legacy of the project in the EU research and innovation applied in the ocean domain.

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